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PATENT SPECIFICATION

394,736

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PROVISIONAL SPECIFICATION.

Improvements in or relating to Testing Combustible Fluids.

I, WILLIAM HELMORE, of Royal Aircraft Establishment, South Farnborough, Hampshire, British Subject, do hereby declare the nature of this invention to be as follows:—

This invention relates to testing combustible fluids and more particularly to a method of and means for ascertaining the spontaneous or self-ignition temperature of combustible liquids in heated air, and the delay time existing at various temperatures between the first contact of the liquid with the heated air and its subsequent ignition or explosion.

The invention has for its chief object to determine the characteristic ignition delay period of fuel oils injected into air at various temperatures, from the temperature at which almost instantaneous ignition occurs, down to the lowest temperature at which the fuel will ignite after long delay, for the purpose of grading fuels or estimating their relative suitability for compression ignition engine use. The method or apparatus may, however, be applied for testing other combustible liquids.

The invention provides a direct basis of comparison, under similar conditions, between various fuels, and shows the order of merit having regard to ease of starting and ignition delay on injection.

The invention has for a further object to avoid bringing the liquid to be tested into contact with heated surfaces, as has hitherto been proposed for determining the lowest spontaneous ignition temperature of fuels as in making the desired determinations according to the present invention, such surfaces may so effect the process of combustion as to render the observations valueless.

According to the present invention the fuel or other combustible liquid (hereinafter generally referred to as fuel) is injected in a finely divided state into air at a predetermined temperature and pressure contained in an explosion vessel, the injection being effected in such a manner that the liquid can ignite in the air without making contact before ignition with any surfaces at a temperature higher than or equal to that of the air. The moment of injection of the fuel is recorded and the time lag existing between the moment of injection and the subsequent ignition or explosion is also recorded.

The vessel may be heated electrically by means of a resistance wire applied to the sides of the vessel, which are lagged or covered, while the bottom end is not lagged.

The fuel is injected under the standard or predetermined pressure through a valve or vessel into the air at atmospheric pressure in the vessel in such a manner that, should it not immediately ignite before passing through the air, its direction of motion causes it to make contact first with a surface which is at a lower temperature than the air in the vessel. The fuel may be injected into an upright cylindrical vessel at the top end and directed towards the bottom end, which is at a lower temperature than the sides, which are at approximately the same temperature as the air. To prevent the fuel from coming into contact with the sides of the vessel, the injection valve or vessel is so designed as to give a spray having a cone angle less than the cone angle subtended by the perimeter of the bottom end of the vessel with the point of entry of the fuel into the vessel. The means for injecting the fuel into the vessel under pressure may consist of an injection pump, which is operated suddenly by a falling weight or other constant force.

The means for indicating the temperature of the air may consist of a thermocouple or the like, which is located in a thermometer tube in the top end of the vessel.

The means for indicating the moment of injection of the fuel may consist of a low tension electric circuit, which is automatically broken or rendered inoperative by the opening of the fuel injection valve, which is located in a jet socket in the centre of the top end of the vessel.

The means for indicating the time lag existing between the moment of injection and the subsequent ignition or explosion of the fuel may consist of a low tension

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circuit, which is automatically broken or rendered inoperative by the rise of pressure in the vessel due to explosion of the fuel.

A separate record of the breaking of each low tension electric circuit may be obtained by sparks from a sparking point in a high tension circuit. The sparks pass to earth, normally through metal plates set in a trough of insulating material, which supports a motor driven paper tape or strip, and thus perforate the latter.

The low tension circuits are interrupted at high frequency by tremblers or other suitable means in series with the respective circuit breaking means abovementioned. One train of sparks representing the time of injection makes a straight line record along the tape owing to the respective sparking point being fixed or stationary. The other train of sparks representing the ignition delay makes a wavy line record along the tape, owing to the respective sparking point being maintained in vibration at a predetermined frequency, by means of a reed and an electro magnet in a low tension circuit. By noting the number of oscillations in the ignition timing wavy record which occur beyond the injection timing straight record, after the circuits have been broken as abovementioned, an accurate measurement of the ignition delay is obtained.

The vessel is open to the atmosphere through an air inlet port at the top end, and a vacuum pump or the like is provided connected to an outlet port at the lower end for drawing in a charge of air before each test, and for withdrawing the products of combustion after each test, and draining off any unoxidised fuel. The air inlet may be arranged tangentially or so as to obtain a scavenging or circulating action and contact with the thermometric device.

In carrying out a test, the temperature of the vessel having been raised by the electric heating means to the highest point which it is desired to investigate (say about 600° C.) the heat is cut off and sufficient time is allowed for temperature conditions to become suitable. A charge of cold air is drawn into the vessel and the vessel is left open to the atmosphere through the air inlet. Sufficient time is allowed to elapse for the temperature of the air charge as read on the thermometric device to reach a maximum and then commence to fall. The tape motor and sparking circuits are then switched on and the air temperature in the vessel noted. The fuel is then injected through the fuel nozzle under pressure (say about 100 atmospheres). The time of injection and of the subsequent explosion are automatically electrically recorded on the travelling tape by the trains of sparks. The time lag between injection and ignition is then read from the record. The products of combustion are evacuated by passing fresh air through the vessel, and a further test is carried out at a lower temperature by repeating the operations.

As the cold air entering the vessel passes across the thermo-couple, the temperature in the thermo-couple indicator falls during the scavenging process, thereby ensuring that in each reading no specially localised heat is absorbed in the thermo-couple.

In this way a series of readings are taken (say about every 10 or 20 degrees) over a gradually falling temperature from the highest required down to the temperature at which ignition fails to occur.

A complete curve showing temperature and ignition delay for a given fuel can be made, and a further series of readings can then be taken with a different fuel.

The explosion vessel may conveniently be say 6 inches internal diameter and say 18 inches internal depth, and have its body part formed of a wrought iron cylinder with screw-on flanges at the ends. The body may be covered with an inner mica insulated layer, over which is wound a heating coil with the convolutions spaced apart by an insulating string and an asbestos insulating layer, the whole being lagged or covered with asbestos and finally with an aluminium casing secured to the end flanges by screws or otherwise. The bottom end of the cylinder is of inverted conical shape and unlagged and the top end of the cylinder is formed with layers of mild steel and asbestos. The bottom end is separated by a joint ring of asbestos from the body part, and is coupled to a drain-pipe for connection to the vacuum pump. The explosion vessel is supported on feet or in any other suitable manner.

The injection valve may be of the type in which the fuel pump pressure lifts a spring loaded valve from its seating in the explosion vessel, any leakage of fuel in the body of the valve being led away. In axial alignment with the valve stem is a central tappet pin, which is guided by the valve casing and projects above the latter into contact with a rocker block, which is pivotally mounted on a fitting secured to the valve casing. The rocker block carries a contact spring, which normally presses against a fixed earthed contact in the injection timing

low tension circuit. When the injection valve is lifted at the moment of injection, the rocker block moves the contact spring and suddenly breaks the circuit. The rocker block also carries a laminated arm, which as the low tension circuit is closed is brought against a permanent magnet, which prevents the circuit being accidentally closed again when the injection valve closes.

The ignition timing low tension circuit may be broken by a circuit breaker, which screws into the top end of the explosion vessel, and comprises a disc valve connected to a tappet pin, which is guided in a central insulated sleeve and projects above the latter against a pivoted contact lever on the fitting. The contact lever is controlled by a hair spring. The contact lever carries a contact, which normally rests on an earthed contact. The disc valve sits on an annular seating and works in a chamber of larger diameter, which is open to the atmosphere through a hole for releasing pressure. When the disc valve is lifted at the moment of explosion of the fuel the contact lever suddenly breaks the circuit.

The fuel injection pump may be of the type in which a plunger traps a small quantity of fuel in a cylinder and forces it past a spring loaded non-return valve in the fuel pipe leading to the injection nozzle, and may be arranged for the plunger to be operated by a weighted lever, which is fulcrummed on the pump casing. In the upright position the weighted lever is clear of the pump plunger, but when the lever is released from this position it falls with a given force into contact with the pump plunger and injects a charge of fuel into the vessel.

The recording mechanism may comprise an electric motor-driven driving wheel or take-up wheel for a paper strip, which passes from a paper feed reel, along a trough of insulating material and under two spring loaded guide rollers one on each side of the driving wheel. The fixed sparking points of the injection timing circuit are arranged at one side of the trough, and the vibrating sparking point of the ignition timing circuit is arranged at the other side of the trough on the vibrating reed which is maintained in oscillation by an electro-magnetic circuit controlled by the reed. The low tension and high tension coils and tremblers for the spark circuits are arranged on the base of the recording mechanism, and a single switch for the electro magnet and a double switch for the low tension timing circuits of and tape motor are also arranged on the base of the recording mechanism.

Dated this 11th day of January, 1932.

A. C. DAY,
Captain,
Agent for the Applicant.

COMPLETE SPECIFICATION.

Improvements in or relating to Testing Combustible Fluids.

I, WILLIAM HELMORE, of Royal Aircraft Establishment, South Farnborough, Hampshire, British Subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to testing combustible fluids and more particularly to a method of and means for ascertaining the spontaneous or self-ignition temperature of combustible liquids in heated air, and the delay time existing at various temperatures between the first contact of the liquid with the heated air and its subsequent ignition or explosion.

The invention has for its chief object to determine the characteristic ignition delay period of fuel oils injected into air at various temperatures, from the temperature at which almost instantaneous ignition occurs, down to the lowest temperature at which the fuel will ignite after long delay, for the purpose of grading fuels or estimating their relative suitability for compression ignition engine use The method or apparatus may, however, be applied for testing other combustible liquids.

The invention provides a direct basis of comparison. under similar conditions, between various fuels, and shows the order of merit having regard to ease of starting and ignition delay on injection.

The invention has for a further object to avoid bringing the liquid to be tested into contact with heated surfaces, as has hitherto been proposed for determining the lowest spontaneous ignition temperature of fuels as in making the desired determinations according to the present invention, such surfaces may so effect the process of combustion as to render the observations valueless.

According to the present invention the fuel or other combustible liquid (hereinafter generally referred to as fuel) is

injected in a finely divided state into air at a predetermined temperature and pressure contained in an explosion vessel, the injection being effected in such a manner that the liquid can ignite in the air without making contact before ignition with any solid surfaces at a temperature higher than or equal to that of the air. The moment of injection of the fuel is recorded and the time of the subsequent ignition or explosion is also recorded. The lag existing between the injection and the subsequent ignition or explosion is thus indicated.

The vessel may be heated electrically by means of a resistance wire applied to the sides of the vessel, which are lagged or covered, while the bottom end is not lagged.

The fuel is injected under the standard or predetermined pressure through a valve or nozzle into the air at atmospheric pressure in the vessel in such a manner that, should it not immediately ignite before passing through the air, its direction of motion ensures that the first surface with which it contacts is one which is at a lower temperature than the air in the vessel. The fuel may be injected into an upright cylindrical vessel at the top end and directed towards the bottom end, which is at a lower temperature than the sides which are at approximately the same temperature as the air. To prevent the fuel from coming into contact with the sides of the vessel, the injection valve or nozzle is so designed as to give a spray having a cone angle less than the cone angle subtended by the perimeter of the bottom end of the vessel with the point of entry of the fuel into the vessel. The means for injecting the fuel into the vessel under pressure may consist of an injection pump, which is operated suddenly by a falling weight or other constant force.

The means for indicating the temperature of the air may consist of a thermocouple or the like, which is located in a thermometer tube in the top end of the vessel.

The means for indicating the moment of injection of the fuel may consist of a low tension electric circuit, which is automatically broken or rendered inoperative by the opening of the fuel injection valve, which is located in a jet socket in the centre of the top end of the vessel.

The means for indicating the time lag existing between the moment of injection and the subsequent ignition or explosion of the fuel may consist of a low tension circuit, which is automatically broken or rendered inoperative by the rise of pressure in the vessel due to explosion of the fuel.

A separate record of the braking of each low tension electric circuit may be obtained by sparks from a sparking point in a high tension circuit. The sparks pass to earth, normally through a metal plate set in a trough of insulating material which supports a motor driven paper tape or strip, and thus perforate the latter.

The low tension circuits are interrupted at high frequency by tremblers or other suitable means. One train of sparks representing the time of injection makes a straight line record along the tape owing to the respective sparking point being fixed or stationary. The other train of sparks representing the ignition delay makes a wavy line record along the tape, owing to the respective sparking point being maintained in vibration at a predetermined frequency, by means of a reed and an electro magnet in a low tension circuit. By noting the number of oscillations in the ignition timing wavy record which occur beyond the injection timing straight record, after the circuits have been broken as abovementioned, an accurate measurement of the ignition delay is obtained.

The vessel is open to the atmosphere through an air inlet port at the top end, and a vacuum pump or the like is provided connected to an outlet port at the lower end for drawing in a charge of air before each test, and for withdrawing the products of combustion after each test, and draining off any unoxidised fuel. The air inlet may be arranged tangentially or so as to obtain a scavenging or circulating action and contact with the thermometric device.

In carrying out a test, the temperature of the vessel having been raised by the electric heating means to the highest point which it is desired to investigate (say about 600° C.) the heat is cut off and sufficient time is allowed for temperature conditions to become stable. A charge of cold air is drawn into the vessel and the vessel is left open to the atmosphere through the air inlet. Sufficient time is allowed to elapse for the temperature of the air charge as read on the thermometric device to reach a maximum and then commence to fall. The tape motor and sparking circuits are then switched on and the air temperature in the vessel noted. The fuel is then injected through the fuel nozzle under pressure (say about 100 atmospheres). The time of injection and of the subsequent explosion are automatically electrically recorded on the travelling tape by the trains of sparks. The time lag between injection and igni-

tion is then read from the record. The products of combustion are evacuated by passing fresh air through the vessel, and a further test is carried out at a lower temperature by repeating the operations.

As the cold air entering the vessel passes across the thermo-couple, the temperature in the thermo-couple indicator falls during the scavenging process, thereby ensuring that in each reading no specially localised heat is absorbed in the thermo-couple.

In this way a series of readings are taken (say about every 10 or 20 degrees) over a gradually falling temperature from the highest required down to the temperature at which ignition fails to occur.

A complete curve showing temperature and ignition delay for a given fuel can be made, and a further series of readings can then be taken with a different fuel.

One form of construction of testing apparatus according to the present invention is illustrated more or less diagramatically and by way of example in the accompanying drawings in which:—

Fig. 1 is a part sectional elevation of the explosion vessel showing the injection timing circuit breaker and the ignition timing circuit breaker in position;

Fig. 2 is a part sectional elevation at right angles to Fig. 1, and Fig. 3 is a plan;

Fig. 4 is an elevation at right angles to Fig. 1 of the injection timing circuit breaker, and Fig 5 is a plan;

Fig. 6 is a sectional elevation at right angles to Fig. 1 of the ignition timing circuit breaker;

Fig. 7 is a wiring diagram;

Figs. 8 and 9 are an elevation and a plan of the recording tape machine;

Figs. 10 and 11 are elevations at right angles to one another of the fuel pump and Fig. 12 is an enlarged sectional elevation of the pump body.

Like reference numerals indicate similar parts wherever repeated in the drawings.

In the arrangement shown the explosion vessel (Figs. 1 to 3) has its body part formed of a wrought iron cylinder 1 with screw-on flanges 2, 3 at the ends. The body is covered with an inner mica insulated layer 4, over which is wound a heating coil 5 with the convolutions spaced apart by an insulating string 6 and an asbestos insulating layer 7. The whole is lagged or covered with asbestos 8 and finally with an aluminium casing 9 secured to the end flanges by screws 10 or otherwise. The bottom end 11 of the cylinder is of inverted conical shape and unlagged, and the top end 12 of the cylinder is formed with layers of mild steel and asbestos. The bottom end is separated by a joint ring of asbestos 13 from the body part, and is coupled to a drain-pipe 14 for connection to a vacuum pump (not shown). The explosion vessel is supported on feet or in other suitable manner.

At the top end the cylinder is provided with a jet socket 15, an ignition timing breaker socket 16, a vent 17 and a thermometer socket 18. The vent 17 is arranged tangentially and inclined to the thermometric device.

The injection valve, which is secured in the jet socket 15 by means of a set screw 19 or in other convenient manner, is of the type in which the fuel pump pressure applied to the inlet 20 lifts a valve 21 from its seating in the explosion vessel, against the action of a spring 22, any leakage of fuel in the body of the valve being led away at the outlet 23. In axial alignment with the valve stem is a central tappet pin 24, which is guided by the valve casing and projects above the latter into contact with a rocker block 25, which is pivotally mounted at 26 on a fitting 27 secured to the valve casing. The rocker block carries a contact spring 28 having a contact 29, which normally presses against a fixed earthed contact 30 in the injection timing low tension circuit. When the injection valve 21 is lifted at the moment of injection, the rocker block moves the contact spring and suddenly breaks the circuit. The rocker block also carries a laminated arm 31, which as the low tension circuit is broken, is brought against a permanent magnet 32 which prevents the circuit from being accidentally closed again when the injection valve closes.

The ignition timing low tension circuit is broken by a circuit breaker, which screws in the socket 16 at the top end of the explosion vessel, and comprises a disc valve 33 connected to a tappet pin 34, which is guided in a central insulated sleeve 35 and projects above the latter against a contact lever 36 pivoted at 37 on the fitting. The contact lever is controlled by a hair-spring (not shown). The contact lever carries a contact 38, which normally rests on an earthed contact 39. The disc valve sits on an annular seating 40 and works in a chamber of larger diameter. When the disc valve is lifted at the moment of explosion of the fuel the contact lever 36 suddenly breaks the circuit.

As shown in Fig. 7, the injection timing low tension circuit containing the contact breaker 28 and comprising a sparking coil with trembler 41 and low tension winding 42 is arranged in parallel

with the ignition timing low tension circuit containing the contact breaker 36 and comprising a sparking coil with trembler 420 and low tension winding 43. One terminal of the circuits is connected to earth at 44, and the other terminal of the circuits is connected through a switch 45 and a battery 46 to earth. The low tension circuits are associated with high tension circuits 47 and 48, which are connected at one terminal to earth at 44, and at the other terminal through sparking points or gaps 49, and 50 to earth at 51 and 52 respectively. The sparking point 49 is fixed and the sparking point 50 is vibratory.

The recording mechanism (Figs. 8 and 9) may comprise an electric motor 53 in circuit with the battery 46 and controlled by a switch 54 coupled to the switch 45. The motor drives a take-up reel 55, on which is wound a paper strip x, which passes from the paper feed reel 56, along a trough 57 of insulating material and under two spring-loaded guide rollers 58, one on each side of the take-up reel. The fixed sparking point 49 of the injection timing circuit is arranged at one side of the trough, and the vibrating sparking point 50 of the ignition timing circuit is arranged at the other side of the trough on a vibrating reed 59 which is maintained in oscillation by an electro-magnetic circuit controlled by the reed. The circuit comprises the reed 59, an adjustable contact 60, electro-magnetic coils 61, a switch 62 and a battery 63. The low tension and high tension coils and tremblers 42, 43, 47, 48, 41 and 420 for the sparking circuits are arranged on the base of the recording mechanism. The switch 62 for the electro-magnet and the double switch 45, 54 for the low tension timing circuits and the tape motor 53 are also arranged on the base of the recording mechanism.

T.1 to T.5 are the terminals of the coils;

T.6 and T.7 Figs. 4 and 5 are the terminals of the injection timing contact breaker;

T.8 and T.9 are the terminals of the ignition timing contact breaker.

The fuel injection pump (Figs. 10 to 12) is of the type in which a plunger 64 traps a small quantity of fuel in a cylinder 65 and forces it past a spring-loaded non-return valve 66 in the fuel pipe 67 leading to the injection nozzle, and is arranged for the plunger to be operated by a weighted lever 68, which is fulcrummed at 69 on the pump casing and falls on to a stop 70. In the upright position the weighted lever is clear of the pump plunger, but when the lever is released from this position it falls with a given force and its lower end 71 comes into contact with a cap 72 on the pump plunger and injects a charge of fuel into the vessel. The fuel may be supplied to the pump inlet 73 from a reservoir 74 through a filter 75; and the stroke of the plunger 64 may be adjusted in known manner.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A method of or means for ascertaining the spontaneous or self-ignition temperature of fuels or other combustible liquids in heated air, and the delay time existing at various temperatures between the first contact of the liquid with the heated air and its subsequent ignition or explosion, wherein the liquid is injected in a finally divided state into air at a predetermined temperature and pressure contained in a vessel, the injection being effected in such a manner that the liquid can ignite in the air without making contact before ignition with any solid surface at a temperature higher than or equal to that of the air, the moment of injection of the liquid being recorded, and the time of the subsequent ignition or explosion being also recorded.

2 Means for testing combustible fluids as claimed in claim 1, wherein the vessel is electrically heated by means of a resistance wire applied to the sides of the vessel, which are lagged or covered, while the bottom end is not lagged.

3. Means for testing combustible fluids as claimed in claim 1, wherein the fuel is injected under a standard or predetermined pressure through a valve or nozzle into the air at atmospheric pressure in the vessel in such a manner that, should it not immediately ignite before passing through the air, its direction of motion ensures that the first surface with which it contacts is one which is at a lower temperature than the air in the vessel.

4. Means for testing combustible fluids as claimed in claim 1, wherein the fuel is injected into an upright cylindrical vessel at the top end and directed towards the bottom end, which is at a lower temperature than the sides, which are at approximately the same temperature as the air, the injection valve being so designed as to give a spray having a cone angle less than the cone angle subtended by the perimeter of the bottom end of the vessel with the point of entry of the fuel into the vessel.

5. Means for testing combustible fluids as claimed in claim 4, wherein the fuel

is injected into the vessel under pressure by means of an injection pump, which is operated suddenly by a falling weight or other constant force.

6. Means for testing combustible fluids as claimed in any of the preceding claims, in which the temperature of the air is indicated by a thermo-couple or the like, which is located in a thermometer tube in the top end of the vessel.

7. Means for testing combustible fluids as claimed in claim 1, wherein the moment of injection of the fuel is indicated by an electric circuit, which is automatically controlled by the opening of the fuel injection valve.

8. Means for testing combustible fluids as claimed in claim 1, wherein the time lag existing between the injection and the subsequent ignition or explosion of the fuel is indicated by an electric circuit, which is automatically controlled by the rise of pressure in the vessel due to explosion of the fuel.

9. Means for testing combustible fluids as claimed in claims 7 and 8, wherein a separate record of the operation of each electric circuit is obtained by sparks in a high tension circuit which mark a movable tape or the like.

10. Means for testing combustible fluids as claimed in claim 9, wherein the sparks pass to earth through a metal plate set in a trough of insulating material, which supports a motor driven paper tape or strip which is perforated by the sparks.

11. Means for testing combustible fluids as claimed in claim 10 wherein the circuits are controlled by tremblers or the like, one train of sparks representing the time of injection making a straight line record, and the other train of sparks representing the ignition delay making a wavy line record.

12. Means for testing combustible fluids as claimed in claim 11 wherein the wavy line record is produced by a sparking point being maintained in vibration at a predetermined frequency, by means of a reed and electro-magnetic means in a low tension circuit.

13. Means for testing combustible fluids constructed substantially as described with reference to and as illustrated in Figs. 1 to 6 of the accompanying drawings.

14. Means for testing combustible fluids as claimed in claim 13 combined with electric recording means constructed substantially as described with reference to and as illustrated in Figs. 7 to 9 of the accompanying drawings.

15. Means for testing combustible fluids as claimed in any of the preceding claims comprising a fuel pump provided with a weighted operating lever substantially as described with reference to and as illustrated in Figs. 10 to 12 of the accompanying drawings.

Dated this 7th day of December, 1932.

A. C. DAY,
Captain,
Agent for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1933.

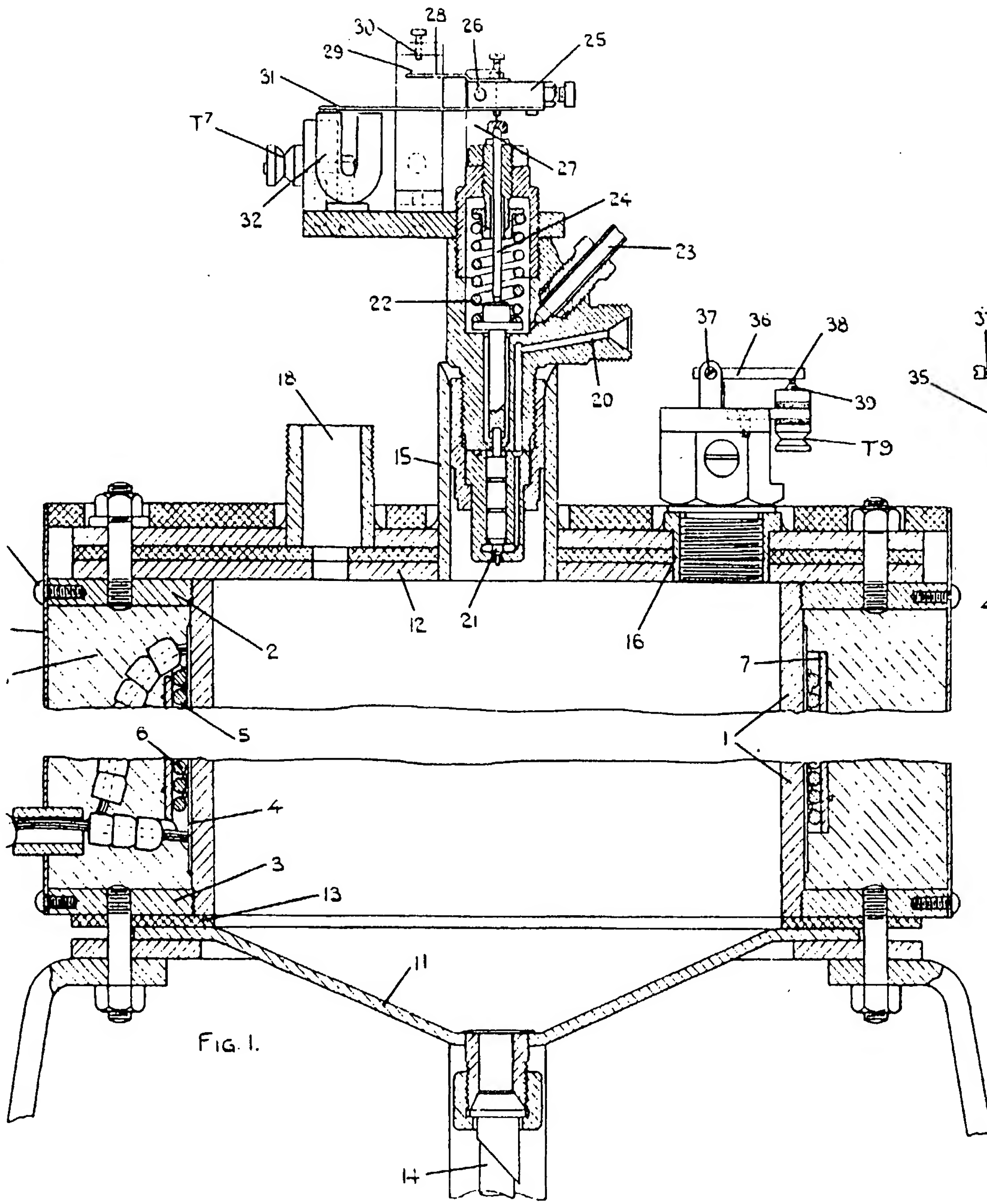

FIG. 1.

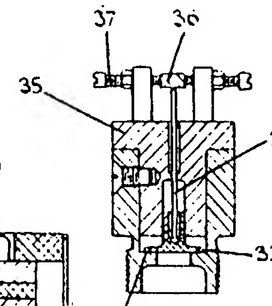

FIG 6

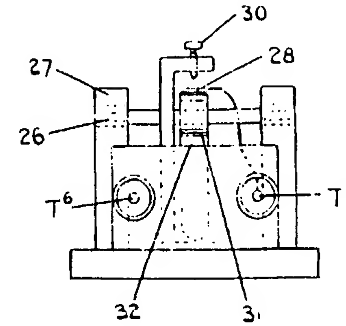

FIG 4.

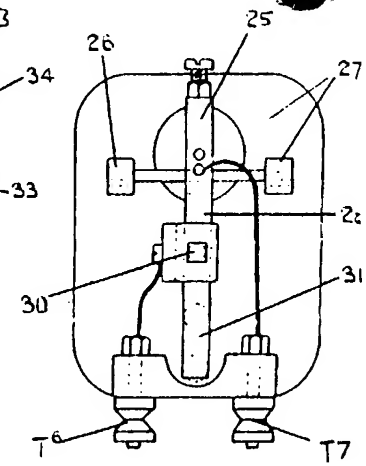

FIG 5

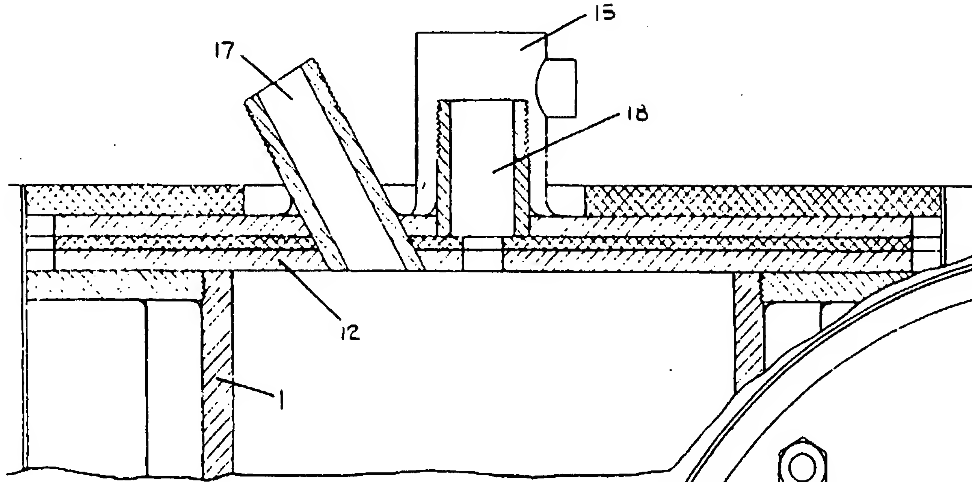

FIG. 2.

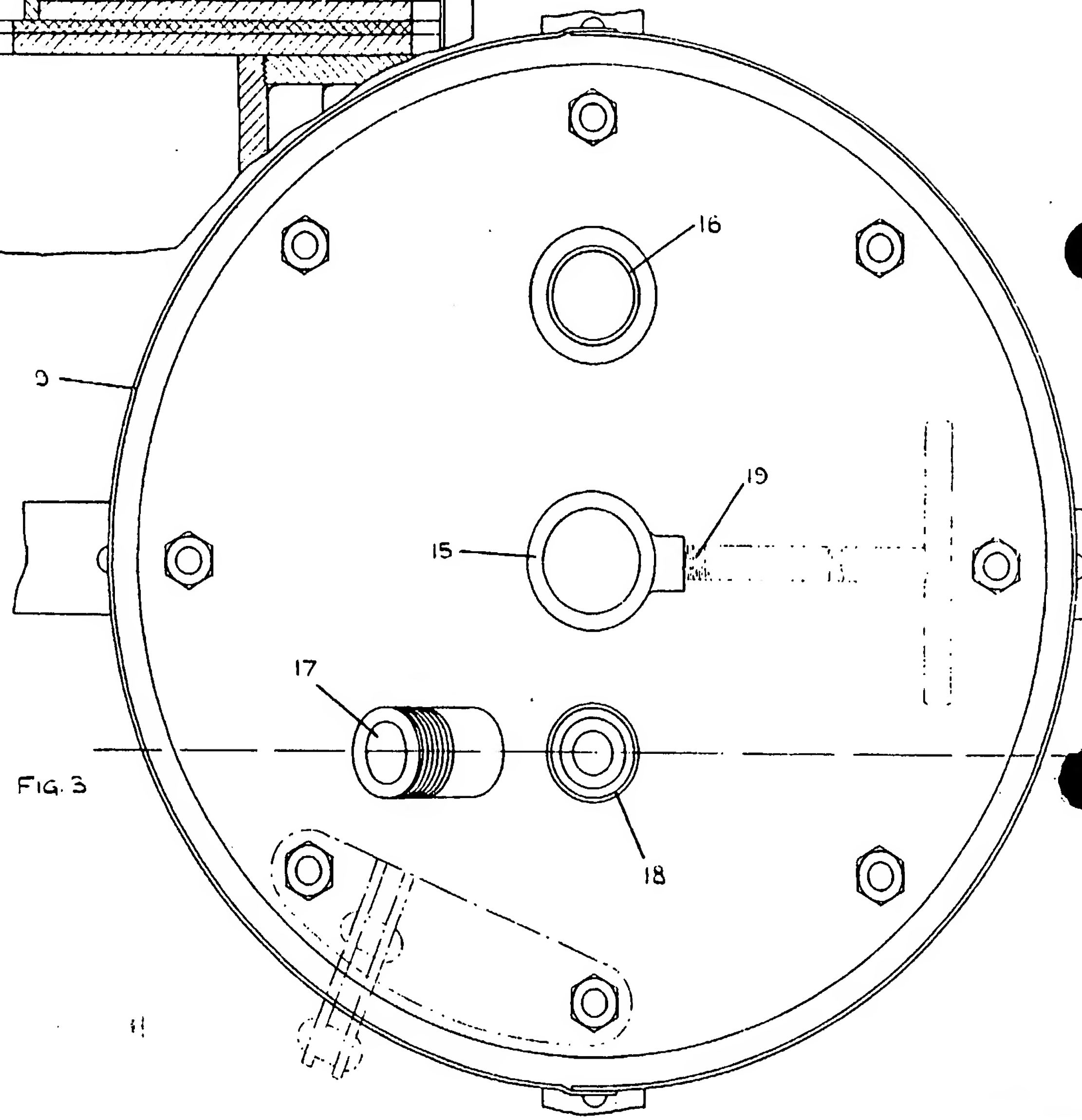

FIG. 3

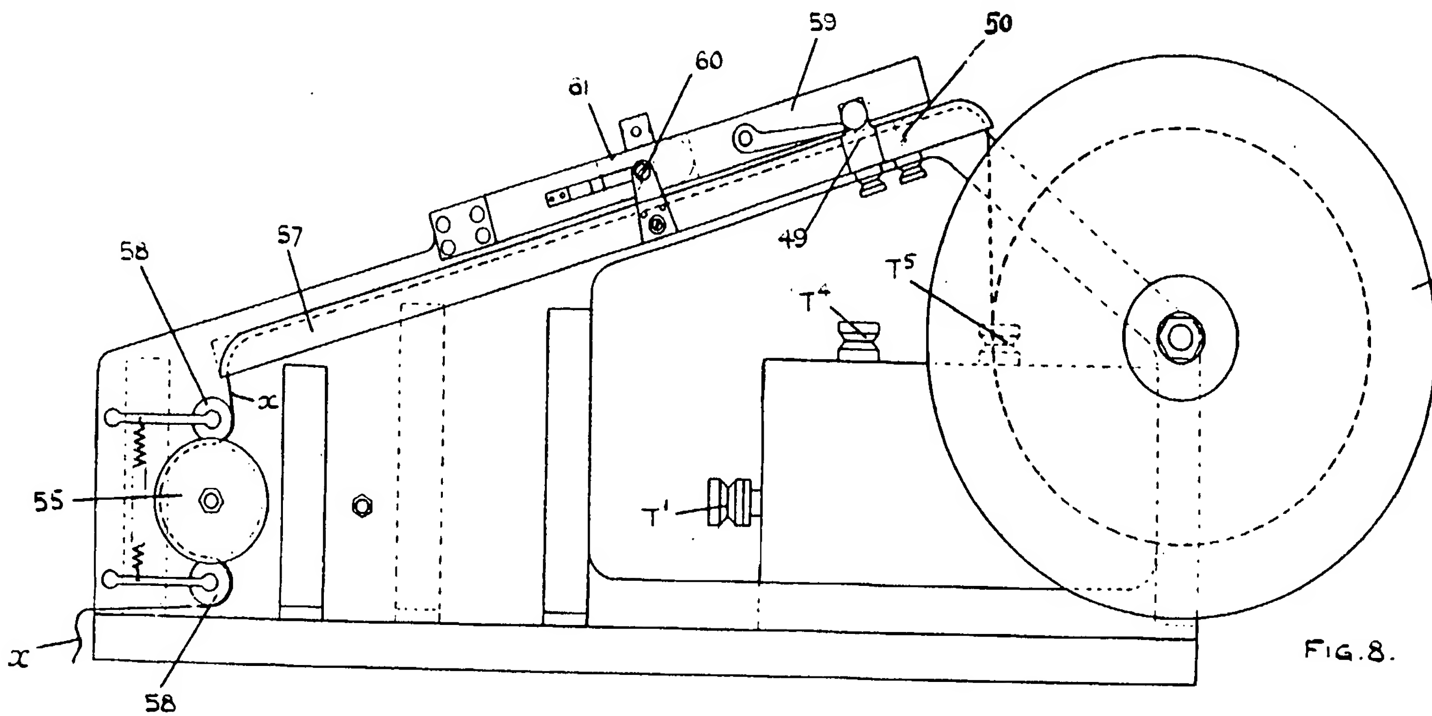

FIG. 8.

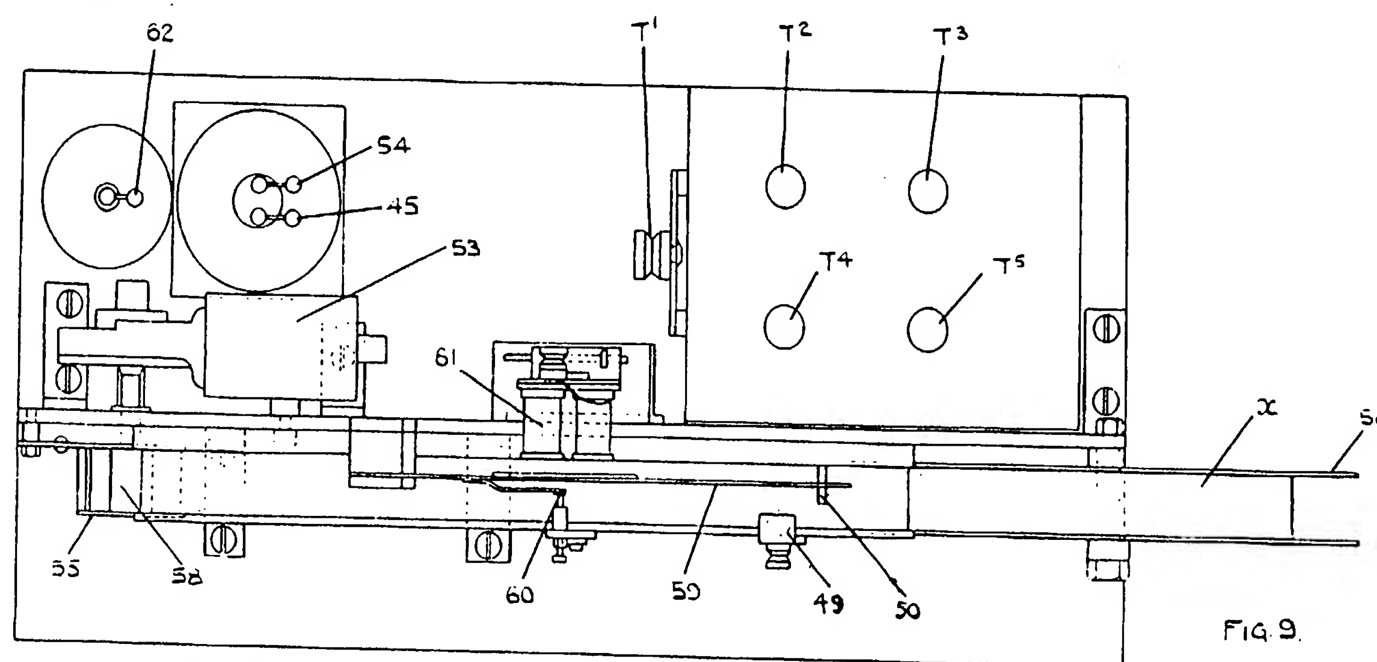

FIG. 9.

Malby & Sons Photo-Litho

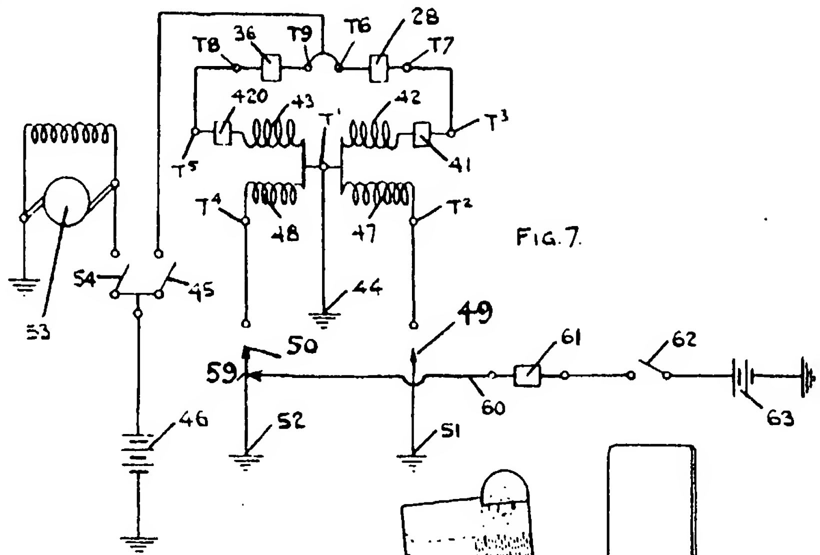

Fig. 7.

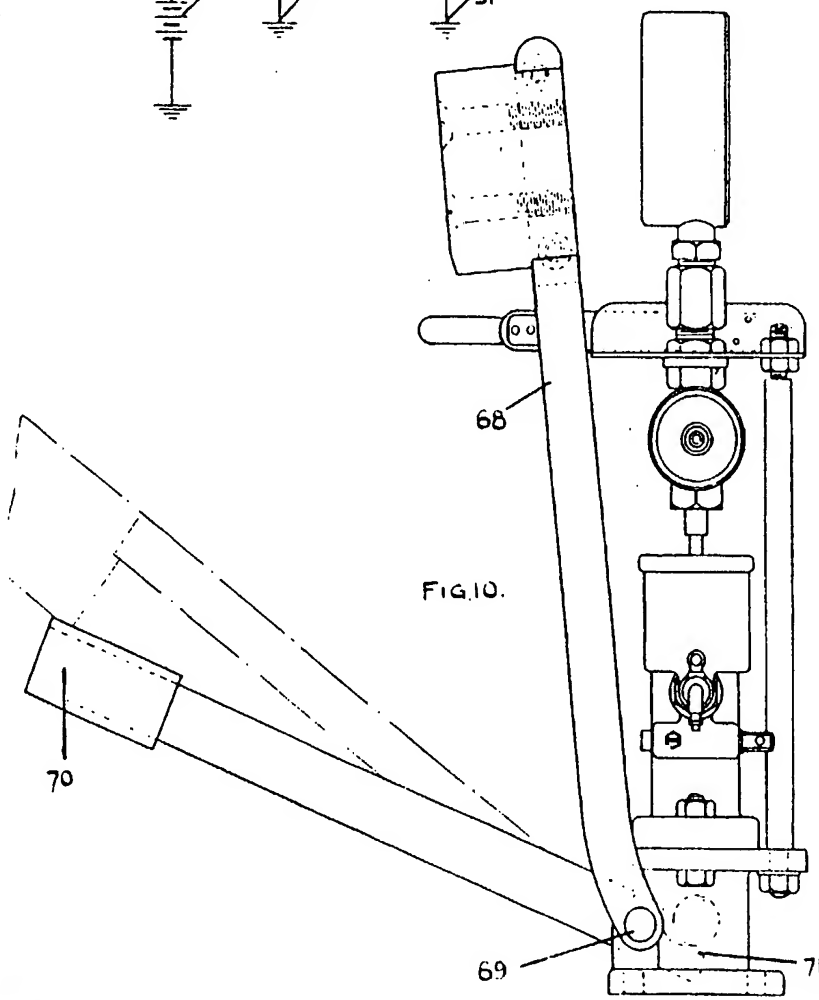

Fig. 10.

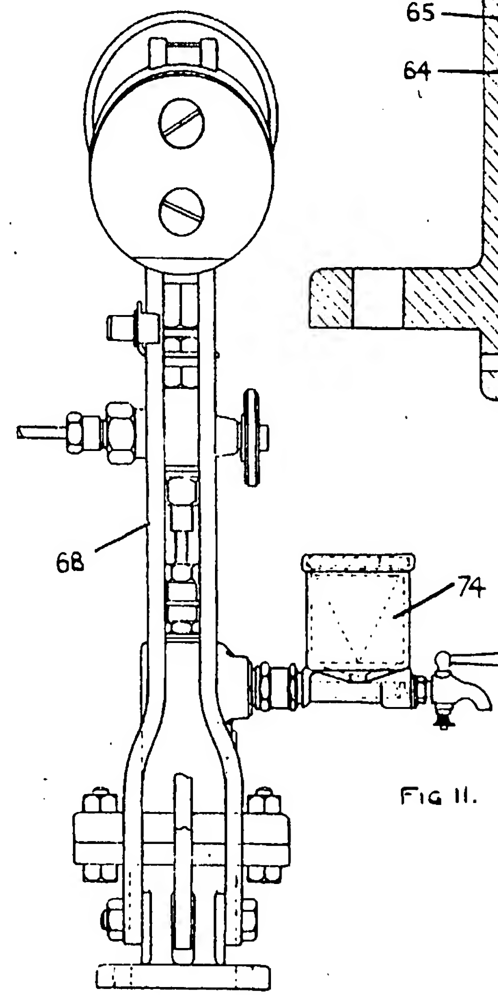

Fig. 11.

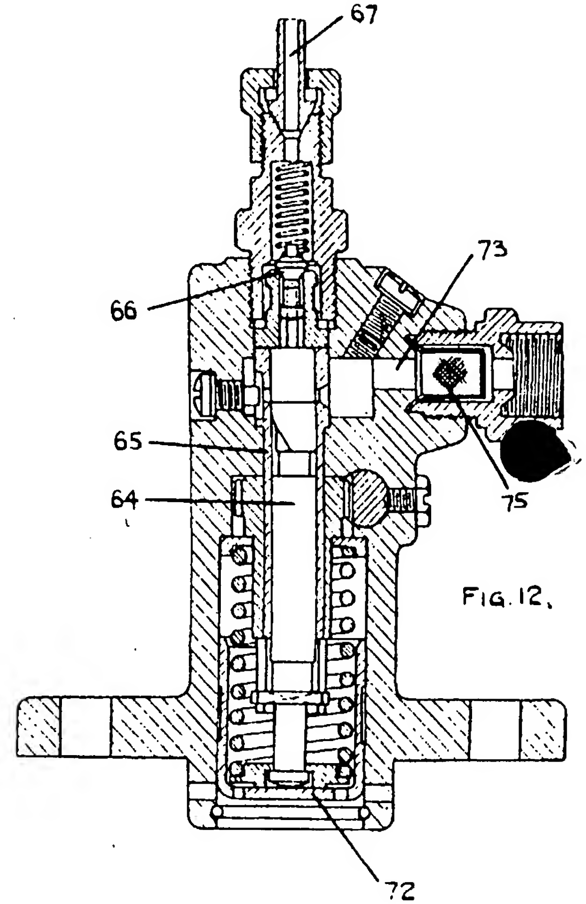

Fig. 12.